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Canker of *Eucalyptus grandis* and *E. saligna* in Surinam caused by *Endothia havanensis**

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COMPENDIO

En 1965, fue detectada en Surinam una seria enfermedad fungosa que causa chancros en el tronco y la muerte en árboles de Eucalyptus grandis *y* E. saligna *plantados en 1962. En 1967, después de un reconocimiento en las plantaciones establecidas de estas especies, se pudo determinar que la enfermedad se presentaba en todas las localidades en las cuales han sido introducidas. El aislamiento, inoculación e identificación probó que el agente causal de la enfermedad es el hongo* Endothia havanensis.

Las observaciones sobre los síntomas y progresos de la enfermedad indican que el hongo penetra por las cicatrices de las ramas o por las grietas de la corteza resultado del crecimiento diametral. Los primeros síntomas pueden ser observados en fustes de más de 5 cm DAP (14 a 18 meses de plantación), alcanzando a producir luego de 2 ó 3 años numerosas infecciones a lo largo del tronco, estas luego se unen. Inicialmente la enfermedad se presenta en forma aislada, provocando luego el ataque de todos los árboles de la plantación, lo que puede producir una mortalidad de 90-100 por ciento en plantaciones de 7 años.

El estudio de la epidemología indicó una correlación notable entre el diámetro del tronco y la incidencia de la enfermedad.

Comparando el habitat natural de estos dos Eucalyptus *con el de Surinam, se puede concluir que estas dos especies no serían recomendables para el establecimiento de plantaciones en zonas tropicales de bajura donde condiciones adversas de crecimiento podrían inducir una susceptibilidad a la* Endothia havanensis. — Los autores.

Introduction

SURINAM (former Dutch Guiana) is situated at the north coast of South America between latitudes 2° and 6°N. The northern part of the country to which this paper refers, has a mean annual rainfall of 2000-2400 mm distributed in a bimodal pattern with the long rains from April to July and the short rains from November to January. The mean temperature is 27°C; there is little seasonal variation. Daily maximum temperatures are highest (32-35°C) in September and October, i.e. towards the end of the long dry season.

In 1961 the Surinam Forest Service planted some *Eucalyptus grandis* Hill ex Maiden and *E. saligna* Sm. on an experimental scale on loamy sands. Where the felled vegetation of mesophytic and sub-mesophytic forest had been burnt, the trees grew exceptionally well. Encouraged by these early results the area was extended in 1962 and 1965 with a total of about 40 ha of both species.

The plantings were situated on humic sands and humic loamy sands in the coastal lowlands of the Coesewijne region at an altitude of about 50 m above sea level. The original forest had been exploited and

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cleared, and the debris burnt. In the 1962 planting one-years-old potted seedlings were spaced 3 x 1.5 m or 5 x 2 m. The 1965 planting was laid out as a trial in which the spacings of 2 x 3 m, 3 x 3 m, and 4 x 3 m were compared.

In 1965 a disease was observed in the 1962 planting. When disease investigations began, in September 1966, the eucalypts at the wider spacing had attained diameters of up to 25 cm and heights of 18-23 m. Nearly all trees appeared to be infected; some had already died. At 3 x 1.5 m the trees were considerably smaller and mortality was over 50 per cent. A few months later the disease was also noticed in the 1965 planting, where diameters were generally 4-8 cm and heights 6-9 m. For interim information the reader is referred to the literature (1, 7).

Symptoms

The progress of the disease as described below is based on observations carried out during nearly three years on 80 trees in the 1962 planting and during one year on 692 trees in the 1965 planting. In addition four trees in different stages of the disease were dissected.

Fig. 1.—*Swollen stem base with bark cracked longitudinally on a tree 25 cm in diameter.*

Fig. 2.—*Infection near a branch scar at 6 m above ground level. Pycnidia are visible as minute black spots.*

The first symptoms appear when the tree attains a diameter of about 5 cm, a stage normally reached 14-18 months after planting. The base of the trunk swells slightly and longitudinal cracks appear (Fig. 1). Soon afterwards reddish-brown to black pycnidia form on the bark. The cracks deepen, and locally a dark red discolouration of bast and young wood tissue is observed; eventually these parts die off. Generally this infection is followed by another one about one metre higher. This second one always develops near a branch scar or a crack caused by thickening (Fig. 2), and it is presumed that these are the ports of entry. In an early stage of the disease a ruby-coloured gum exudes. As the gum is water-soluble, the colour spreads along the trunk, turning it characteristically reddish.

The tree reacts by forming callus round the site of infection, leading to bulging of the outer layer of the

Fig. 3.—*Stem canker at 1.80 m.*

bark. Finally this layer is shed and a canker is left on the trunk (Fig. 3). In this stage a sectorial dark brown discolouration may be observed in cross-section (Fig. 4). After two or three years as many as five apparently separate cankers of up to 5 dm^2 may appear along the stem. Eventually these infections coalesce.

No clear relation was observed between the crown density and the external trunk damage caused by the cankers. Open crowns may indicate either less vigorously growing trees or infected ones. However, heavily infected but vigorously growing trees may still show a nearly full foliage.

The patogen

Isolations from infected bark tissue which were made on potato dextrose agar (PDA) or prune agar, consistently yielded a fungus that *in vitro* produced similar pycnidia as observed on the bark. Even from very young infections without pycnidia, the fungus could be recovered.

A culture and a piece of bark from a canker were sent to the Centraalbureau voor Schimmelcultures, Baarn, The Netherlands, where the fungus was identified as *Endothia havanensis* Bruner.

Although Kobayashi and Ito (6) published some useful supplementary notes on Bruner's (4) limited description of *E. havanensis*, more detailed data on the Surinam isolate seem appropriate.

Cultures of the fungus on PDA are white. After five days they turn orange, and orange pycnidia with long necks (0.2 - 1 mm) are produced in concentric rings. After about ten days the pycnidia turn black and conidia are extruded in a cream-coloured exudate. Conidia are formed on ramified conidiophores. They are minute, one-celled, rod-shaped with rounded ends, hyaline, 3.6 x 1.4μ (2.9 - 4.5 x 0.8 - 1.7μ).

On the bark from cankers numerous pycnidia may be present (Figs. 5 and 6) which are often compound, possessing two, and sometimes three long necks (1-2 mm).

In addition black perithecia identical in shape with the simple pycnidia, are found. Asci are subclavate or oblong-fusoid, 45 x 6.5μ (32 - 53 x 5.0 - 7.5μ), eight-spored, aparaphysate. Ascospores are oblong-elliptic, rounded at the ends, hyaline, one-septate, 7.2 - 3.6μ (5.5 - 8.5 x 1.8 - 3.8μ).

Five about one-year-old potted seedlings were inoculated with the isolated fungus through a wound at the base of the stem. After three months all inoculated plants had died. Cankers were present at the inoculation site. From these plants the same fungus was re-isolated. Five control plants that had been merely wounded, developed no disease symptoms.

Epidemiology

In 1967 a survey pointed out that the disease occurred at all localities in Surinam where *Eucalyptus grandis* and *E. saligna* had been introduced (Jarikaba, Nickerie, Blakawatra, Zanderij, and Coesewijne). Recently an early stage of infection was observed in an 18-month old experimental planting of *E. citriodora* Hook. The fungus appeared on some of the larger trees, which measured approximately 7 m in height and 10 cm in diameter. However, none of a few old trees of *E. alba* Reinw. ex Blume in the Botanical Garden of Paramaribo have shown the disease symptoms.

The observations in both plantings studied in detail showed that the disease occurred scattered over the area; there were no marked foci. In the younger planting a marked correlation was observed between diameter growth and disease incidence (Table 1). Thus in the plots with the widest spacing (3 x 4 m), which soon after planting showed the most vigorous growth, the disease spread at first faster than in the other plots (Table 2).

Mortality progressed during a number of years as illustrated by observations made in the 1962 planting

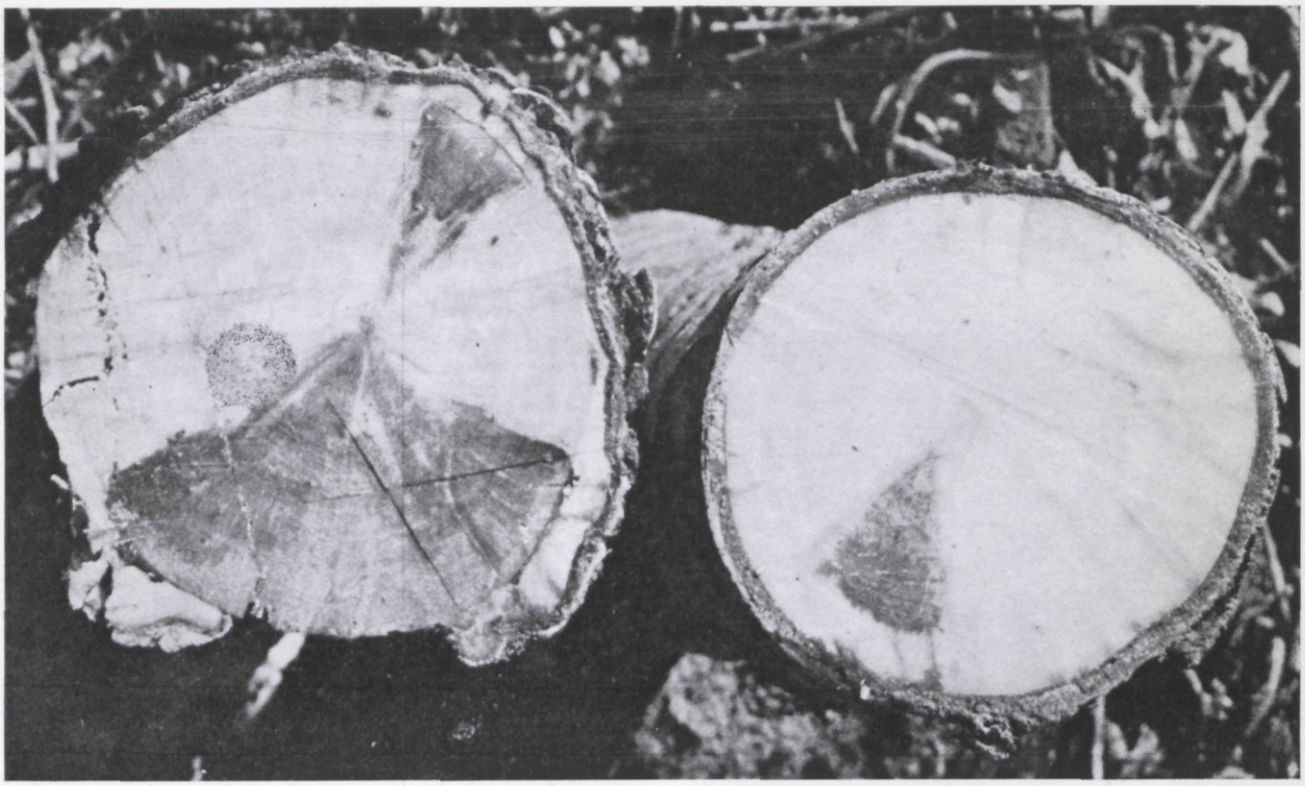

Fig. 4.—*Sectorial discolouration of wood tissue in cross-sections at 10 and 60 cm caused by a canker at the stem base.*

(Table 3). All trees still alive by May 1969 proved to be more or less heavily infected. Diameter growth had stopped or nearly so. There is little doubt that after another two or three years no living trees will be left. However, some trees whose above-ground parts had died off completely, were sprouting from the root collar.

In the 1965 planting a fertilizer trial including a single application of a NPK-fertilizer, dolomitic limestone, and trace elements in different, combinations, was carried out in 1967. One year later no significant effects had been noticed neither on growth nor on disease incidence.

Table 1.—Relation between tree diameter and infection by *Endothia* 20 months after planting, spacing 3 x 4 m (totals of two 40 x 40 m plots).

Diameter at 1.30 m. (cm)	Number of trees		Percentage infected
	total	infected	
1 — 3	13	0	0
3 — 5	30	0	0
5 — 7	56	20	36
7 — 9	73	38	52
9 — 11	56	39	70
11 — 13	16	13	81
13 — 15	5	5	100
1 — 15	249	115	46

Discussion

In his description of *Endothia havanensis,* Bruner (4) reports the fungus to occur among others on several eucalypts: *Eucalyptus botryoides* Sm., *E. rostrata* Schlecht (=*E. camaldulensis* Dehnh.), *E. microphylla* Willd. (?), *E. robusta* Sm., and *E. occidentalis* Endl. It was usually found on the bark of dead or injured trees, but was sometimes also noticed on the rough bark of large healthy ones. All collections were made in Cuba. In Japan Kobayashi and Ito (6) found the

Table 2.—Progress of infection in an experimental planting during 13 months of observation at three different spacings (planting date December 1965).

Spacing (m)	Number of trees (March 1967)	Trees infected (%)						
		III/67	VI/67	VIII/67	X/67	XII/67	II/68	IV/68
3 x 2	246	1	13	28	34	41	53	65
3 x 3	182	4	8	26	38	45	57	65
3 x 4	264	8	24	46	48	57	64	71

Fig. 5.—Endothia havanensia *on bark. Shadows of longnecked pycnidia are visible as black lines.*

fungus on dead bark of *E. globulus* Lab. Apparentiy it was not considered a serious threat to the infected trees. As far as known *Endothia havanensis* is not mentioned in the literature on eucalypt diseases (3, 10).

As a result of the wide-spread occurrence of the fungus in Surinam and the seriousness of the disease, the question arises whether the local environment deviates essentially from that in the other countries where the two eucalypts occur.

E. saligna and *E. grandis* have their natural habitat along the eastern coast of Australia. The former is found between the latitudes 28 and 35°S the latter between 17 and 32°S (5, 9, 12). *E. saligna* is a species of warm temperate to sub-tropical areas of equable temperatures with a moderately high rainfall (1000-1500 mm annually) which occurs mainly in summer. *E. grandis* is a sub-tropical species occurring in regions with a good summer-rainfall (1000-1750 mm) and no extremes of temperature. Both are essentially lowland

Table 3.—Mortality in two plots of 40 trees each during the period September 1966 - May 1969 (planting date December 1962).

Date	Number of trees alive	Annual mortality (%)
September 1966	80	*)
February 1967	68	36
February 1968	38	44
May 1969	21	37

*) About 50% of the trees planted lacking.

species, though at its northern limit *E. grandis* is found up to 800 m, and *E. saligna* up to 1200 m above sea level. Both eucalypts require moderately fertile to fertile, moist soils.

It is clear that there is a considerable difference in climate between the tropical lowlands of Surinam and ment the species are submitted to a marked seasonal these eucalypts' natural habitat. In their natural environvariation in temperature (warm summers and cool to moderately warm winters), whereas in Surinam temperatures are high all year round. Rainfall is higher in Surinam. Moreover in Australia temperature and rainfall maxima coincide; in Surinam the opposite occurs.

E. grandis and *E. saligna* have been introduced into many sub-tropical as well as tropical countries (2, 9, 10, 11). More or less extensive plantations occur in Brazil, Rhodesia, Congo, South and East Africa. Within the tropics, the best results always seem to be attained

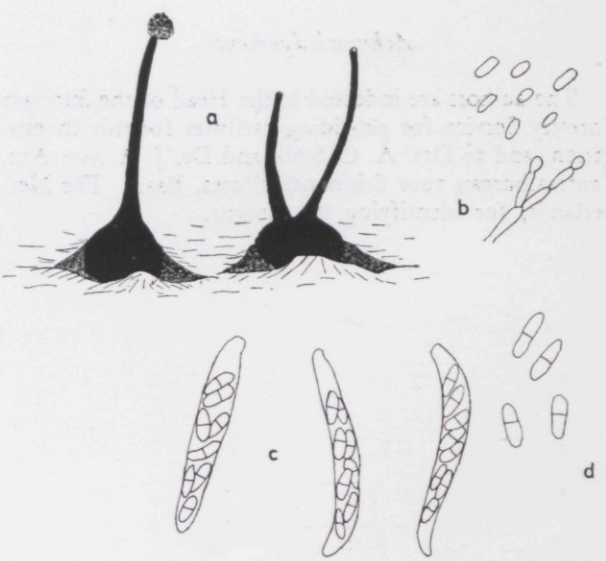

Fig. 6.—Endothia havanensis. *a. pycnidia, b. conidia and conidiophore, c. asci, d. ascospores.*

at high altitudes, i.e.from 800 - 1500 m above sea level. Lowland plantations have often ended in failure. From this is may be concluded that *E. grandis* and *E. saligna,* though very adaptable species, are not suited to planting in tropical lowland areas, where adverse growing conditions may induce susceptibility to *Endothia havanensis*. Though no adequate data could be obtained to support this hypothesis it may well be that outside Surinam *Endothia* too has been contributing to failures with these eucalypts.

At present, work in eucalypt planting trials in Surinam is focusing on other species such as *E. alba* Reinw. ex Blume and *E. deglupta* Blume.

Summary

Experimental plantings of *Eucalyptus grandis* and *E. saligna* in Surinam were extended in 1962 and 1965.

In 1965 a serious disease causing stem cankers and resulting in death of the trees was observed in the 1962 planting. In 1967 a survey pointed out that the disease occurred at all localities in Surinam where *E. grandis* and *E. saligna* had been introduced.

Isolation, inoculation and identification proved *Endothia havanensis* to be the cause.

Close observation of symptoms and progress of the disease made it clear that the fungus penetrates near branch scars or near cracks in the bark caused by thickening.

A study of the epidemiology showed a marked correlation between diameter growth and disease incidence.

From a comparison between the natural habitat of both eucalypts and the Surinam circumstances it is concluded that *E. grandis* and *E. saligna* are not suited to planting in tropical lowland, where adverse growing conditions may induce susceptability to *Endothia havanensis*.

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Literature cited

1. ANONYMOUS. Forestry. *In:* Report for the years 1965, 1966 and 1967 of the Centre for Agricultural Research in Surinam. CELOS Bulletin 5:15-18. 1968.

2. BRASNETT, N. V. and CHAMPION, H. Choice of tree species. FAO Forestry Development Paper 13. Rome, 1958. 307 p.

3. BROWNE, F. G. Pests and diseases of forest plantation trees. Clarendon Press. Oxford. 1968. 1330 p.

4. BRUNER, S. C. A new species of *Endothia.* Mycologia 8:239-42. 1916.

5. HALL, N., JOHNSTON, R. D. and MARRYATT, ROSEMARY. The natural occurrence of the eucalypts. Canberra, 1963.

6. KOBAYASHI, T. and ITO, K. Notes on the genus *Endothia* in Japan. I. Species of Endothia collected in Japan. Bulletin of the Government Forest Experiment Station Meguro 92:87-97. 1956.

7. MAAS, P. W. Th. Phytopathologie en Nematologie. *In:* V. K. R. EHRENCRON (Ed.) Jaarverslag 1966. Medelingen Landbouwproefstation Suriname 42. 1967.

8. MAGNANI, G. Diseases of *Eucalyptus.* Diseases of widely planted forest trees. FAO/IUFRO Symposium on internationally dangerous forest diseases and insects. 1964. pp. 159-167.

9. METRO, A. Les eucalyptus dans les reboisements. FAO Forestry Development Paper 11. Rome 1954. 403 p.

10. PENFOLD, A. R. and WILLIS, J. L. The eucalypts. London. Leonard Hill. 1961. 550 p.

11. STREETS, R. J. Exotic forest trees in the British Commonwealth. Oxford. Clarendon Press. 1962. 765 p.

12. VAN LAAR, A. *Eucalyptus saligna* in South Africa: an investigation into the silviculture and economics. Annale Universiteit Stellenbosch, 36(1). 1961.